**Center Independent Research & Development: GSFC IRAD**

# A Thermal Imaging Instrument with Uncooled Detectors

Completed Technology Project (2016 - 2020)

## Project Introduction

In this proposed work, we will perform an instrument concept study for sustainable thermal imaging over land with uncooled detectors. We will define the science and instrument requirements and we will evaluate three different uncooled detector technologies, which have been conceptualized by our team (and are presently at low-TRL). We will also build-up and demonstrate the materials characterization infrastructure required for progressing the TRL of a chosen uncooled detector technology.

The National Research Council's Committee on Implementation of a Sustained Land Imaging Program has identified the inclusion of a thermal imager as critical for both current and future land imaging missions. Such an imaging instrument operating in two bands located at approximately 11 and 12 microns (for example, in Landsat 8, and also Landsat 9 when launched) will provide essential information for furthering our hydrologic understanding at scales of human influence, and produce field-scale moisture information through accurate retrievals of evapotranspiration (ET). Landsat 9 is slated to recycle the TIRS-2 instrument launched with Landsat 8 that uses cooled quantum well infrared photodetectors (QWIPs) operating at ~43-65 K temperature, hence requiring expensive and massive cryocooler technology to achieve its required spectral and spatial accuracies (Fig. 1).

In contrast, we aim to conceptualize and develop a thermal imaging instrument which leverages recent and imminent technology advances in uncooled detectors. Such detector technology will offer the benefit of greatly reduced instrument cost, mass, and power at the expense of some acceptable loss in detector sensitivity. It would also allow a thermal imaging instrument to be fielded on board a low-cost platform, e.g., a CubeSat. In addition, it would enable capitalizing on the greater number of launch opportunities available for launch vehicles like the Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA).

## Anticipated Benefits

**We will develop an instrument concept with uncooled detectors that does not require a cryocooler.** Investment in this IRAD is the first step in the technology road map for developing a TRL-6 thermal instrument suitable for the Landsat 10 instrument call (in approximately 6-7 years) and beyond. Pending the outcome of the instrument concept study, and manpower availability, we will submit either a mid-year FY17 IRAD or a follow-on second-year IRAD to begin a focused materials characterization and optimization effort to advance the TRL of our chosen uncooled detector technology. In addition, this work will allow our team to formulate a competitive proposal to further develop the TRL of uncooled detector technology, in the upcoming (late-summer 2016) ESTO ACT proposal call.

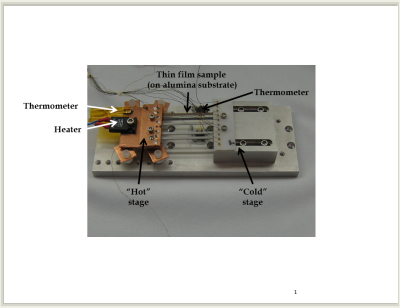


Fig. 2: Apparatus we will automate and use to measure the intrinsic Seebeck coefficient of our films. Our thin films substrates will be suspended between a 'hot' and a 'cold' stages and we will measure the voltage output for a given…

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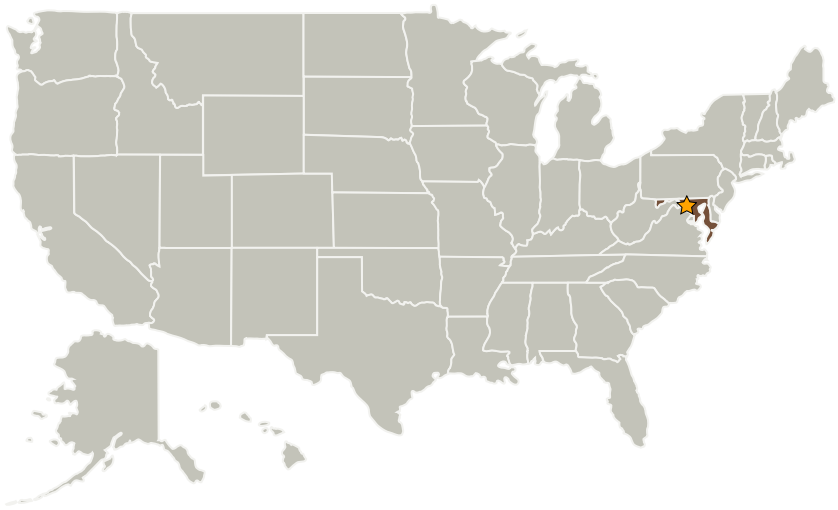
## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| ★Goddard Space Flight Center(GSFC) | Lead Organization | NASA Center | Greenbelt, Maryland |

| Primary U.S. Work Locations |
|---|
| Maryland |

## Project Transitions

**October 2016:** Project Start

## Organizational Responsibility

**Responsible Mission Directorate:**

Mission Support Directorate (MSD)

**Lead Center / Facility:**

Goddard Space Flight Center (GSFC)

**Responsible Program:**

Center Independent Research & Development: GSFC IRAD

## Project Management

**Program Manager:**

Peter M Hughes

**Project Managers:**

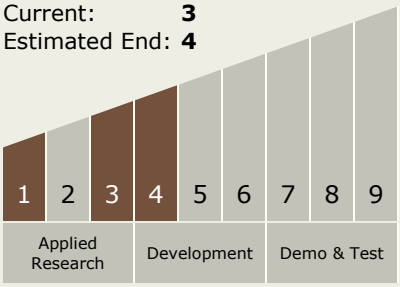
Matthew J Mcgill
Julia W Breed

**Principal Investigator:**

Alicia T Joseph

## Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **4**



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**September 2020:** Closed out

**Closeout Summary:** We fabricated sub-micron thick doped silicon samples bon ded to a supporting substrate and measured the thermoelectric materials proper ties of these samples at various dopant concentrations. Our main milestone of t his work was the confirmation of thermoelectric properties similar to bulk proper ties as a function of dopant concentration. We fabricated the first prototype dop ed-Si thermopile detectors and have assembled an optical testbed and packagin g for these prototype devices. The purpose of the Goddard Space Flight Center's Internal Research and Development (IRAD) program is to support new technolo gy development and to address scientific challenges. Each year, Principal Invest igators (PIs) submit IRAD proposals and compete for funding for their developm ent projects. Goddard's IRAD program supports eight Lines of Business: Astrop hysics; Communications and Navigation; Cross-Cutting Technology and Capabilit ies; Earth Science; Heliophysics; Planetary Science; Science Small Satellites Tec hnology; and Suborbital Platforms and Range Services. Task progress is evaluat ed twice a year at the Mid-term IRAD review and the end of the year. When the funding period has ended, the PIs compete again for IRAD funding or seek new sources of development and research funding, or agree to external partnerships and collaborations. In some cases, when the development work has reached th e appropriate Technology Readiness Level (TRL) level, the product is integrated i nto an actual NASA mission or used to support other government agencies. The technology may also be licensed out to the industry. The completion of a project does not necessarily indicate that the development work has stopped. The work could potentially continue in the future as a follow-on IRAD; or be used in collab oration or partnership with Academia, Industry, and other Government Agencie s. If you are interested in partnering with NASA, see the TechPort Partnerships d ocumentation available on the TechPort Help tab. http://techport.nasa.gov/help

## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

## Target Destination

Earth

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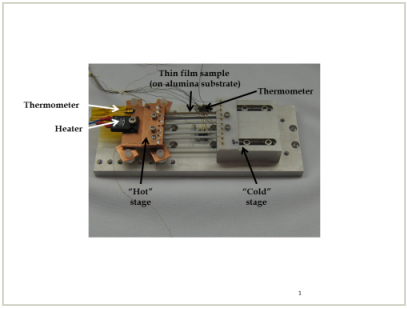
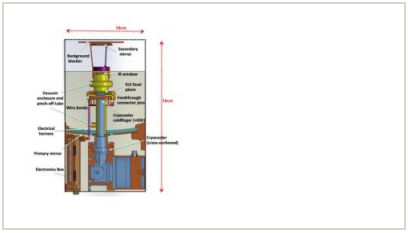
## Images




**Apparatus: Image 2**
Fig. 2: Apparatus we will automate and use to measure the intrinsic Seebeck coefficient of our films. Our thin films substrates will be suspended between a 'hot' and a 'cold' stages and we will measure the voltage output for a given temperature diffe
*(https://techport.nasa.gov/image/40361)*



**Schematic of a conceptual thermal imager: Image 1**
Fig. 1: Schematic of a conceptual thermal imager, which employs cryogenic strained super-lattice detectors (a successor to QWIPs). The cryocooler comprises ≥ 70% of the mass and volume of the imager and requires ≥ 40 W of power. We will develop an i
*(https://techport.nasa.gov/image/40360)*

## Links

NASA Goddard Facebook
*(https://www.facebook.com/NASA.GSFC )*

NASA Goddard Twitter
*(https://twitter.com/intent/follow?screen_name=NASAGoddard)*

## Project Website:

http://sciences.gsfc.nasa.gov/sed/